IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant	:	Sirignano et al
Appl. No.	:	10/766,132
Filing Date	:	January 27, 2004
Title	:	Miniature, Liquid-Fuel Combustion Chamber
Group Art Unit	:	3749
Examiner	:	Sara Sachie Clarke
Docket No.	:	703538.4032

RULE 132 DECLARATION

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Sir:

1. I, Paul Ronney, am a Professor of Aerospace and Mechanical Engineering at the University of Southern California. My Curriculum Vitae and a representative list of publications are attached as Exhibit 1.

2. I have no financial interest in the above-referenced patent application ("the application").

3. I am personally acquainted with Professors William A. Sirignano and Derek Dunn-Rankin at the University of California Irvine. Professors Sirignano and Dunn-Rankin are the inventors/applicants listed in the application.

4. I have reviewed the application as filed on January 27, 2004. The subject matter of the application is directed generally to the field of combustors and specifically to miniature combustors on a sub-centimeter scale. I am of the opinion that one of ordinary skill in the art would possess an MS or PhD degree in such fields of study as mechanical engineering, aerospace engineering, chemical engineering, chemistry or physics.

5. I am of the opinion that the application describes and teaches to one of ordinary skill in the art a novel sub-centimeter sized combustor chamber and method of operation. The currently pending claims are directed, as claimed in claim 1, to a miniature combustor comprising a "chamber having a lateral dimension transverse to a major flow direction within the chamber that is sub-centimeter" and, in dependent claim 2, "the lateral dimension is in a range of about 1.0 to 3.0 millimeters." The claims, as claimed in claim 15, are also directed to a combustion process in a combustion chamber that "has a lateral dimension transverse to a major flow direction within the chamber that is sub-centimeter." The dimensional aspects of the claimed miniature combustion chambers create different operational phenomena that prevent the principles of larger combustion chamber systems from operating in smaller, miniaturized combustion chambers.

6. At the claimed dimensions, i.e., sub-centimeter lateral dimension, which are comparable to known quenching distances, the surface-to-volume ratio for the combustion chamber is so large that a flame is typically not sustainable within the chamber due to the large heat transfer losses to the chamber walls. To overcome this wall quenching phenomenon, the applicants teach and claim injecting a liquid, fuel or inert, as a film that covers the entire or substantially the entire area of the chamber walls. With a liquid film applied to and maintained on the chamber walls, some of the heat transferred from hot combustion gases is captured by the liquid film protecting the

chamber walls and, thus, reducing heat loss to the chamber walls. When the liquid is a fuel, the heat transferred from the hot combustion gases will serve to aid in vaporization of the liquid fuel so it is burned before it exits the chamber.

7. Current technology for larger systems does not rely on liquid fuel filming on the chamber walls (though some fuel is intentionally vaporized from intake manifolds in IC engines as part of the charge preparation). Instead, to keep the ratio of liquid surface area to liquid volume large enough to sustain high fuel vaporization rates, the fuel is typically injected as a spray. The intention is to vaporize the liquid as a spray before very much liquid deposits on the walls or solid surfaces of the chamber. If the fuel were filmed in these larger engines or combustors, the surface area of the liquid would not be large enough to sustain the needed vaporization rate for combustion. Because the S/V ratio of any wall film will grow as the volume of the combustor decreases, the liquid fuel film in combustors in the sub-centimeter size range tends to provide a liquid surface area for vaporization comparable to a vaporizing spray. Furthermore, the liquid fuel film protects against heat losses at the wall and, thus, quenching, that a vaporizing spray does not. Simply scaling existing combustion systems down to the lateral dimensions taught and claimed would result in increased heat loss and subsequent combustion failure due to quenching. Some sprayed droplets might impact the combustor walls but, without filming on the entire or substantially the entire chamber wall, heat protection of all parts of the wall would not occur. Impacting droplets might only lead to less complete and thereby less efficient combustion.

8. I am of the opinion that it would not be obvious to one of ordinary skill in the art at the time of the applicant's invention to have scaled the apparatuses of Schirmer (1959), Meurer, Schirmer (1986) and Rao to applicant's dimensions. For combustion chambers, dimensions cannot

simply scale in proportion. Physics which these authors never discuss and, in fact, clearly ignore become important. Thus, the teaches of these references would not lead one of ordinary skill in the art to the miniature combustion chamber and process taught and claimed by the applicants.

9. Schirmer (1959) does not mention the importance of heat loss and quenching. It is clear that he has not considered the scaling effects resulting in quenching since he prescribes the addition of air to quench the flame in the chamber thereby implying the non-existence of an important wall-quenching effect.

10. It is also clear that Schirmer (1959) is directed to larger-scale combustors than those taught and claimed by the applicants. For instance, at column 2, lines 18—20 Schirmer (1959) indicates the presence of a "highly turbulent shear interface of the fuel and the air." It is common textbook knowledge that turbulence occurs when the Reynolds number, which increases in direct proportion to the length scale of the flow passage, is large, or the onset of turbulence in a fluid occurs only when the product of the velocity and the representative length dimension exceed a threshold. Another indication that Schirmer (1959) is directed to larger-scale combustors occurs at column 2, Lines 22—25, where velocities up to 250 feet per second are deemed allowable. In a chamber dimension of ten centimeters or less, this allows about a millisecond or less for combustion to occur, which for typical turbojet fuels is usually too short a time to accomplish the vaporization, mixing of fuel vapor and oxidizer, and chemical oxidation processes which in totality and in sequence form the combustion process. Thus, Schirmer (1959) clearly relates only to the physics that operate in devices on a scale much larger than those taught and claimed by the applicants.

11. The statement at column 3, Lines 1-14 of Schirmer (1959) regarding "self-regulation of the wall temperature" is not correct. That is, self-regulation occurs as applicants indicate by

maintaining a stable liquid film on the wall. Schirmer (1959) does not teach maintaining a stable liquid film on the wall. To the contrary, Schirmer (1959) states at column 2, lines 11—22:

> Broadly speaking, my combustion apparatus permits the introduction of fuel uniformly onto the entire inner surface of the primary combustion chamber through a porous liner spaced from the inner wall of the chamber, and the introduction of air in the form of a vortex into the primary combustion chamber so that the flow of air spirals or swirls coaxially through the primary combustion chamber. Combustion apparently is effected at the highly turbulent shear interface of the fuel and the air. The shear interface, and therefore the combustion occurs near the surface of the porous wall and in the mixing zone.

It is common text book knowledge that at the prescribed flow rates of Schirmer (1959), the shear forces would be such that the layer of fuel on the chamber walls will become unstable and break-up into droplets for vaporization and, thus, heat protection of chamber walls is lost.

12. Meurer also does not address the issues of heat loss and quenching associated with smaller dimensions. Specifically, Meurer does not prescribe that the combustion chamber wall should be fully covered by the liquid to reduce heat losses. Moreover, Meurer teaches cooling the combustion wall with air, thus indicating an acceptance of heat loss to the walls. Scaling of Meurer would result in combustion failure due to quenching as a result.

13. Schirmer (1976) addresses gaseous fuel and atomized liquid fuel only. As discussed above, simply scaling of Schirmer's device to the dimensions of applicants, and nothing more, would result in combustion failure due to quenching.

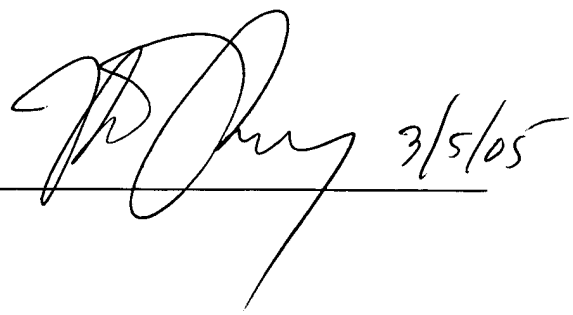
14. Rao considers a situation in his vortex device where the liquid is not the fuel or a chemical reactant. Only heat transfer and no mass transfer occur between the liquid and the core gas flow. The class of devices discussed in Rao certainly does not include combustors.

15. Because internal combustion has the potential to simultaneously provide high power density and high energy density, which is desirable of power sources for devices requiring personal

power such as cellular telephones, PDAs, laptop computers, etc., many researchers have attempted to explore it as a method for power generation on a miniature scale. Examples of such exploration include, a micro-gas turbine with a combustor volume of 0.04 cubic centimeters (see, Waitz et al., 120 Jnl. Fluids Engr., 109-117 (1998)), a mini (0.078 cc displacement) and a micro (0.0017 cc displacement) rotary engine (see Fu et al., 99F023 Combustion Inst., Western States Sect., Fall Mtg. (1999)), a microrocket with a 0.1 cubic centimeter combustion chamber (see Lindsay et al., IEEE Cat. No. 01CH37090, 606-610 (2001)), and a micro Swiss roll burner (see Ahn et al., Proceedings of the Combustion Institute, Vol. 30, pp. 2463-2472 (2004). Although these devices have demonstrated the plausibility of internal combustion as a personal power source, they are not able to perform at efficiencies that make them competitive with the best available batteries. Thus, there is still a long felt, unsatisfied need for a miniature power source with high power and energy density like the miniature combustor of the claimed invention.

I certify under penalty of perjury that the information submitted in this declaration is all true and correct.

Respectfully Submitted,

Dated: March 5, 2005 By: 

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RESEARCH INTERESTS

Combustion, micro-scale power generation and propulsion, biophysics and biofilms, turbulence, internal combustion engines and control systems, low-gravity phenomena, radiative transfer.

PROFESSIONAL EXPERIENCE

2/96 - 12/97: Payload Specialist Astronaut (Alternate) - trained for Spacelab mission MSL-1, (launched as STS-83 4/4/97 - 4/8/97, re-flew as STS-94 on 7/1/97 - 7/16/97) to conduct combustion, fluids, and materials science experiments. Served as crew communicator for experiment operations during both missions.

6/00 - present: Professor, Department of Aerospace and Mechanical Engineering, University of Southern California, Los Angeles, CA

9/94 - 5/00: Associate Professor, Department of Aerospace and Mechanical Engineering, University of Southern California, Los Angeles, CA

9/93 - 8/94: Research Associate Professor, Department of Mechanical Engineering, University of Southern California, Los Angeles, CA

8/86 - 8/93: Assistant Professor, Department of Mechanical and Aerospace Engineering, Princeton University, Princeton, NJ.

11/85 - 4/86: Research Associate, Chemistry Division, U.S. Naval Research Laboratory, Washington, D.C.

9/83 - 10/85: National Research Council Resident Research Associate, NASA Lewis (Glenn) Research Center, Cleveland, OH.

8/78 - 9/79: Systems Integration Engineer, Ford Aerospace & Communications Corp., Newport Beach, CA.

HONORS , AWARDS, PROFESSIONAL ACTIVITIES

Principal Investigator for Structure Of Flame Balls At Low Lewis-number (SOFBALL) space flight experiment on STS-83 (April 4-8, 1997), STS-94 (July 1-16, 1997) and STS-107 (January 16 – February 1, 2003) Space Shuttle missions.

Principal Investigator for Radiative Enhancement Effects on Flame Spread (REEFS) space flight experiment scheduled for the International Space Station, c. 2008.

Fellow, Institute of Physics

Member of editorial boards, *Combustion and Flame, Combustion Theory and Modelling, Microgravity Science and Technology, Progress in Energy and Combustion Science*

Co-chair, colloquium on "New Concepts in Combustion Technology," 29th and 30th International Symposium on Combustion, 2002 and 2004.

Member of NASA Office of Biological and Physical Research Scientific Advisory Council; Chair, Physical Sciences Subcommittee

Best poster award (out of 90), *Dynamics Days Europe 2003*, Palma de Majorca, Spain, Sept. 24-27, 2003

Institution of Mechanical Engineers (U.K.) Starley Premium Award, 1994 (for the best paper published in the Journal of Automobile Engineering, 1994).

Princeton Engineer's Council Excellence in Teaching Award, 1990.

National Science Foundation Presidential Young Investigator, 1987 - 1992

EDUCATION

9/79 - 3/83 Massachusetts Institute of Technology, Cambridge, MA
Sc.D. in Aeronautics and Astronautics, March 1983; DuPont Fellowship, Upham Fellowship

9/78 - 6/79 California Institute of Technology, Pasadena, CA
M.S. in Aeronautics, June 1979; Guggenheim Fellowship

9/77 - 6/78 University of California, Berkeley, CA
B.S. in Mechanical Engineering, June 1978; Tau Beta Pi, Pi Tau Sigma, Phi Beta Kappa, Dean's List

9/74 - 6/77 University of California, Irvine, CA, Mechanical Engineering major

PUBLICATIONS

Book Chapters (3)

Ronney, P. D., "Combustion Phenomena at Microgravity," Chapter 12 in: *Physics of Fluids in Microgravity* (R. Monti, Ed.), Gordon and Breach, Reading, U.K., 2002, pp. 371-431.

Ronney, P. D., "Premixed-Gas Flames," in: *Microgravity Combustion: Fires in Free Fall* (H. Ross, Ed.), Academic Press, London, U.K., 2001, pp. 35-82.

Ronney, P. D., "Some Open Issues in Premixed Turbulent Combustion," in: Modeling in Combustion Science (J. D. Buckmaster and T. Takeno, Eds.), Lecture Notes In Physics, Vol. 449, Springer-Verlag, Berlin, 1995, pp. 3-22.

Refereed Journal Publications (61)

Shao, Z, Haile, S., Ahn, J., Ronney, P. D., Zhan, Z., Barnett, S. A., "A thermally self-sustained micro Solid-Oxide Fuel Cell with high power density," submitted to *Nature* (2005).

Wang, F., Liu, J. B., Sinibaldi, J., Brophy, C., Kuthi, A., Jiang, C., Ronney, P. D., Gundersen, M. A., "Transient Plasma Ignition of Quiescent and Flowing Fuel Mixtures," to appear in *IEEE Transactions on Plasma Science* (2005).

Liu, J. B., Wang, F., Li, G., Kuthi, A., Gutmark, E. J., Ronney, P. D., Gundersen, M. A., "Transient plasma ignition," to appear in *IEEE Transactions on Plasma Science* (2005).

Ahn, J., Eastwood, C., Sitzki, L., Ronney, P. D., "Gas-phase and catalytic combustion in heat-recirculating burners," *Proceedings of the Combustion Institute,* Vol. 30, pp. 2463-2472 (2004).

Ronney, P. D., "Analysis of non-adiabatic heat-recirculating combustors," *Combustion and Flame*, Vol. 135, pp. 421-439 (2003).

Maruta, K., Takeda, K., Ahn, J., Borer, K., Sitzki, L, Ronney, P. D., Deutschman, O., "Extinction Limits of Catalytic Combustion in Microchannels," *Proceedings of the Combustion Institute*, Vol. 29, pp. 957-963 (2002).

Son, Y., Ronney, P. D., "Radiation-Driven Flame Spread Over Thermally-Thick Fuels in Quiescent Microgravity Environments," *Proceedings of the Combustion Institute*, Vol. 29, pp. 2587-2594 (2002).

Weinberg, F. J., Rowe, D. M., Min, G., Ronney, P. D., "On thermoelectric power conversion from heat re-circulating combustion systems," *Proceedings of the Combustion Institute*, Vol. 29, pp. 941-947 (2002).

Kagan, L., Sivashinsky, G. I., Ronney, P. D., "Activation Energy Effect on Flame Propagation in Large-Scale Vortical Flows," *Combustion Theory and Modelling*, Vol 6, pp. 479-485 (2002).

Ji, C., Ronney, P. D., "Modeling of Engine Cyclic Variation by a Thermodynamic Model" in: *Spark Ignition and Compression Ignition Engine Modeling* (SP-1720), Society of Automotive Engineers, 2002. Also *SAE Paper 2002-01-2736* (2002).

Honda, L. K. and Ronney, P. D., "Mechanisms of concurrent-flow flame spread over solid fuel beds," *Proceedings of the Combustion Institute,* Vol. 28, pp. 2793-2801 (2000).

Nayagam, V., Balasubramaniam, R., and Ronney, P. D., "Diffusion Flame-Holes," *Combustion Theory and Modelling*, Vol. 3, pp. 727-742 (1999).

Liu, J.-B. and Ronney, P. D., "Premixed Edge-Flames in Spatially Varying Straining Flows," *Combustion Science and Technology*, Vol. 144, pp. 21-46 (1999).

Ronney, P. D., "Flame Structure Modification and Quenching By Turbulence," *Combustion Science and Technology* (Japanese edition), Vol. 6 (Supplement), pp. 53-76 (1999).

Wu, M. S., Ronney, P. D., Colantonio, R. and VanZandt, D., "Detailed Numerical Simulation of Flame Ball Structure and Dynamics," *Combustion and Flame*, Vol. 116, pp. 387-397 (1999).

Abid, M., Wu, M. S., Liu, J. B., Ronney, P. D., Ueki, M., K. Maruta, K., Kobayashi, H., Niioka, T. and VanZandt, D. M., "Experimental and Numerical Study of Flame Ball IR and UV Emissions," *Combustion and Flame*, Vol. 116, pp. 348-359 (1999).

Vedarajan, T. G., Buckmaster, J. D. and Ronney, P. D., "Two-dimensional Failure Waves and Ignition Fronts in Premixed Combustion," *Twenty-Seventh International Symposium on Combustion*, Combustion Institute, Pittsburgh, 1998, pp. 537-544.

Wu, M.-S., Liu, J. B. and Ronney, P. D., "Numerical Simulation of Diluent Effects on Flame Ball Structure and Dynamics," *Twenty-Seventh International Symposium on Combustion*, Combustion Institute, Pittsburgh, 1998, pp. 2543-2550.

Ju, Y., Masuya, G. and Ronney, P. D., "Effects of Radiative Emission and Absorption on the Propagation and Extinction of Premixed Gas Flames" *Twenty-Seventh International Symposium on Combustion*, Combustion Institute, Pittsburgh, 1998, pp. 2619-2626.

Buckmaster, J. D. and Ronney, P. D., "Flame Ball Drift in the Presence of a Total Diffusive Heat Flux," *Twenty-Seventh International Symposium on Combustion*, Combustion Institute, Pittsburgh, 1998, pp. 2603-2610.

Ronney, P. D., "Understanding Combustion Processes Through Microgravity Research," *Twenty-Seventh International Symposium on Combustion*, Combustion Institute, Pittsburgh, 1998, pp. 2485-2506 **(invited paper).**

Ronney, P. D., Wu, M. S., Pearlman, H. G. and Weiland, K. J., "Experimental Study of Flame Balls in Space: Preliminary Results from STS-83," *AIAA Journal*, Vol. 36, pp. 1361-1368 (1998).

Ronney, P. D., "Premixed Laminar and Turbulent Flames at Microgravity," *Space Forum*, Vol. 4, pp. 49-98 (1998).

Aldredge, R. C., Vaezi, V. and Ronney, P. D., "Premixed-Gas Flame Propagation in Turbulent Taylor-Couette Flow," *Combustion and Flame*, Vol. 115, pp. 395-405 (1998).

Honda, L. K. and Ronney, P. D., "Effects of Ambient Atmosphere on Flame Spread at Microgravity," *Combustion Science and Technology*, Vol. 133, pp. 267-291 (1998).

Shay, M. L. and Ronney, P. D., "Nonpremixed Flames in Spatially-Varying Straining Flows," *Combustion and Flame*, Vol. 112, pp. 171-180 (1998).

Liu, J. B., Ronney, P. D., "Modified Fourier Transform Method for Interferogram Fringe Pattern Analysis," *Applied Optics*, Vol. 36, pp. 6231 - 6241 (1997).

Kim, J. S., Williams, F. A., Ronney, P. D., "Diffusional-Thermal Instability of Diffusion Flames," *Journal of Fluid Mechanics*, Vol. 327, pp. 273-302 (1996).

Lim, E. H., McIlroy, A., Ronney, P. D., Syage, J. A., "Detailed Characterization of Minimum Ignition Energies of Combustible Gases Using Laser Ignition Sources," in: Transport Phenomena in Combustion (S. H. Chan, Ed.), Taylor and Francis, 1996, pp. 176-184.

Shy, S. S., Jang, R. H., Ronney, P. D., "Laboratory Simulation of Flamelet and Distributed Models for Premixed Turbulent Combustion Using Aqueous Autocatalytic Reactions", Combustion Science and Technology, Vol. 113-114, pp. 329 - 340 (1996).

Haslam, B. D., Ronney, P. D., "Fractal Properties of Propagating Fronts in a Strongly Stirred Fluid," *Physics of Fluids*, Vol. 7, pp. 1931-1937 (1995).

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Lempert, W. R., Magee, K., Ronney, P. D., Gee, K. R., Haugland, R. P., "Flow Tagging Velocimetry In Incompressible Flow Using PHoto-Activated Nonintrusive Tracking Of Molecular Motion (PHANTOMM)," *Experiments in Fluids*, Vol. 18, pp. 249-257 (1995).

Ronney, P. D., Greenberg, J. B., Zhang, Y., Roegner, E. V., "Flame Spread Over Thin Solid Fuels in Partially Premixed Atmospheres," *Combustion and Flame*, Vol. 100, pp. 474-484 (1995).

Zhu, J. Y., Ronney, P. D., "Simulation of Front Propagation at Large Non-dimensional Flow Disturbance Intensities," *Combustion Science and Technology*, Vol. 100, pp. 183-201 (1994).

Pearlman, H. G., Ronney, P. D., "Near-Limit Behavior of High Lewis-Number Premixed Flames in Tubes at Normal and Low Gravity," *Physics of Fluids*, Vol. 6, pp. 4009-4018 (1994).

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Lozinski, D., Buckmaster, J. D., Ronney, P. D., "Absolute Flammability Limits and Flame Balls in Optically Thick Mixtures," *Combustion and Flame*, Vol. 97, pp. 301-316 (1994).

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Ronney, P. D., Shoda, M., Waida, S. T., Durbin, E. J., "Throttleless Premixed-Charge Engines: Concept and Experiment," *Journal of Automobile Engineering, (Proceedings of the Institution of Mechanical Engineers, Part D)*, Vol. 208, pp. 13-24 (1994). **This paper received the 1994 Starley Premium Award from the Institution of Mechanical Engineers (U.K.), for the best paper published in the *Journal of Automobile Engineering* in 1994.**

Abbud-Madrid, A., Ronney, P. D., "Premixed Flame Propagation in an Optically-Thick Gas," *AIAA Journal*, Vol. 31, pp. 2179-2181 (1993).

Greenberg, J. B., Ronney, P. D., "Analysis of Lewis Number Effects in Flame Spread," *International Journal of Heat and Mass Transfer*, Vol. 36, pp. 315-323 (1993).

Sloane, T. M., Ronney, P. D., "A Comparison of Ignition Phenomena Modelled with Detailed and Simplified Kinetics," *Combustion Science and Technology*, Vol. 88, pp. 1-13 (1993).

Buckmaster, J. B., Gessman, R., Ronney, P. D., "The Three-Dimensional Dynamics of Flame Balls," *Twenty-Fourth International Symposium on Combustion*, Combustion Institute, Pittsburgh, 1992, pp. 53-59.

Chen, R. H., Mitchell, G. B., Ronney, P. D., "Diffusive-Thermal Instability and Flame Extinction in Non-Premixed Combustion," *Twenty-Fourth International Symposium on Combustion*, Combustion Institute, Pittsburgh, 1992, pp. 213-221.

Shy, S. S., Ronney, P. D., Buckley S. G., Yakhot, V., "Experimental Simulation of Premixed Turbulent Combustion Using Aqueous Autocatalytic Reactions," *Twenty-Fourth International Symposium on Combustion*, Combustion Institute, Pittsburgh, 1992, pp. 543-551.

Ronney, P. D., Shoda, M., Waida, S. T., Westbrook, C. K., Pitz, W. J., "Knock Characteristics of Liquid and Gaseous Fuels in Lean Mixtures," *Transactions of the Society of Automotive Engineers*, Vol. 100, Part 4, pp. 557-568 (1992). Also *SAE Paper No. 912311*, 1991.

Ronney, P. D., Yakhot, V., "Flame Broadening Effects on Premixed Turbulent Flame Speed," *Combustion Science and Technology*, Vol. 86, pp. 31-43 (1992).

Zhang, Y., Ronney, P. D., Roegner, E., Greenberg, J. B., "Lewis Number Effects on Flame Spreading Over Thin Solid Fuels," *Combustion and Flame*, Vol. 90, pp. 71-83 (1992).

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Abbud-Madrid, A., Ronney, P. D., "Effects of Radiative and Diffusive Transport Processes on Premixed Flames Near Flammability Limits," *Twenty Third Symposium (International) on Combustion*, Combustion Institute, 1990, pp. 423-431.

Farmer, J. N., Ronney, P. D., "A Numerical Study of Unsteady Nonadiabatic Flames," *Combustion Science and Technology*, Vol. 73, pp. 555-574 (1990).

Ronney, P. D., "Near-Limit Flame Structures at Low Lewis Number," *Combustion and Flame*, Vol. 82, pp. 1-14 (1990).

Buckmaster, J. D., Joulin, G., Ronney, P. D., "Effects of Heat Loss on the Structure and Stability of Flame Balls," *Combustion and Flame*, Vol. 79, pp. 381-392 (1990).

Ronney, P.D., Sivashinsky, G.I., "A Theoretical Study of Propagation and Extinction of Nonsteady Spherical Flame Fronts," *SIAM Journal on Applied Mathematics*, Vol. 49, pp. 1029-1046 (1989).

Ronney, P.D., "On the Mechanisms of Flame Propagation Limits and Extinction Processes at Microgravity," *Twenty Second Symposium (International) on Combustion*, Combustion Institute, 1988, pp. 1615-1623.

Ronney, P.D., "Effect of Chemistry and Transport Properties on Near-Limit Flames at Microgravity," *Combustion Science and Technology*, Vol. 59, pp. 123-141 (1988).

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Ronney, P.D., "Effect of Gravity on Laminar Premixed Gas Combustion II: Ignition and Extinction Phenomena," *Combustion and Flame*, Vol. 62, pp. 120-132 (1985).

Ronney, P.D., Wachman, H. Y., "Effect of Gravity on Laminar Premixed Gas Combustion I: Flammability Limits and Burning Velocities," *Combustion and Flame*, Vol. 62, pp. 107-119 (1985).

Patents (5)

Ronney, P. D., Cohen, A. L., Evans, J. D., "Fuel Formulation for Use with Portable Electronic Devices," pending.

Haile, S., Ronney, P. D., Shao, Z., "Micropower generator and method for forming the same," pending (utility patent application filed June 23, 2004).

Ronney, P. D., "Thermal transpiration pump for gaseous material driven by chemical reaction," pending (utility patent application filed May 29, 2004, application 10/857,670)

Cohen, A., Ronney, P. D., Frodis, U., Sitzki, L, Meiburg, E., Wussow, S., "Microcombustor and combustion-based thermoelectric microgenerator," U. S. Patent No. 6,613,972, Sept. 2, 2003.

Durbin, E. J., Ronney, P. D., "Method and Apparatus For Force or Torque Control of a Combustion Engine," U.S. Patent No. 5,184,592, Feb. 9, 1993.

Invited Conference Presentations (24)

"Excess Enthalpy Combustion for Microscale Power Generation," *2nd Zeldovich Memorial International Conference on Combustion and Detonation*, Moscow, Russia, September 2004.

"Fuel-flexible single-chamber solid oxide fuel cells," *DARPA Workshop on Fuel-Flexible Sustainable Microscale Power Sources*, Vail, CO, September 2004.

"Swiss-roll thermal management systems," *DARPA workshop on Thermal Management for Micro- and Meso-power Systems*, Chicago, IL, May 2004.

"Thermal and Chemical Cells," *Electric Power in Vivo Workshop and Symposium*, Los Angeles, CA, February 2004.

"Effect of Gravity on Combustion Processes," *Congrès Français de Mécanique*, Nice, France, Sept. 1 - 4, 2003.

"Flame balls: Recent experimental and computational results," *Gordon Conference on Gravitational Effects in Physico-Chemical Systems* , July 27 – 31, 2003, New London, CT.

"Premixed-gas flames at microgravity," *First International Symposium on Microgravity Research & Applications in Physical Sciences and Biotechnology*, Sorrento, Italy, September 10 - 14, 2000.

"Combustion research: from earth to outer space and back," *Environmental Molecular Sciences Symposia and First EMSL User Meeting*, Richland, Washington, July 21-24, 1999.

"Diffusive and hydrodynamic instabilities of flames," *Symposium on Chemical Waves, Fronts and Patterns*, Fall National Meeting , American Chemical Society, New Orleans, LA, Aug. 22-26, 1999.

"Understanding Combustion Processes Through Microgravity Research: Recent Advances and Future Challenges," *Gordon Conference on Gravitational Effects in Physico-Chemical Systems* , June 27 – July 2, 1999, Henniker, New Hampshire.

"Instabilities and Dynamics of Front Propagation in Narrow Channels," *Gordon Conference on Oscillations and Dynamic Instabilities in Chemical Systems,* June 6-11, 1999, Barga, Italy.

"Dynamics of Front Propagation in Narrow Channels," *Modeling of Reactive Fronts: At the Interface of Mathematics, Physics and Chemistry*, April 19 - 21, 1999, Lyon, France.

"Understanding Combustion Processes Through Microgravity Research," plenary lecture, 27th International Symposium on Combustion, Boulder, CO, August 2 - 7, 1998.

"Structure Modification and Quenching of Premixed Gas Flames by Turbulence," Japan Conference on Premixed Turbulent Combustion, Tokyo, Japan, November 17, 1997.

"Combustion Experiments in Space," 36th Israel Annual Conference on Aerospace Sciences, Tel-Aviv/Haifa, Israel, February 21-22, 1996.

"Combustion Experiments on Spacelab Mission MSL-1," 6th International Space Conference of Pacific Basin Societies, December 6-8, 1995, Marina del Rey, CA.

"Propagation and Extinction Mechanisms of Premixed Turbulent Flames," Joint U.S./Japan Workshop on Mathematical Modeling in Combustion and its Interaction with Numerical Computation, July 25 - 29, 1994, Kaapa, Hawaii.

"Laser versus Conventional Ignition of Flames," SPIE Symposium on Laser Applications in Combustion and Combustion Diagnostics, Jan. 16-23, 1992, Los Angeles, CA.

"Effects of Ambient Atmosphere on Flame Spreading and Extinction," Workshop on Spacecraft Fire Safety Risk Analysis Assessment, Oct. 31 - Nov. 1, 1991, Los Angeles, CA.

"New Premixed Gas Combustion Phenomena," Gordon Research Conference on Gravitational Effects in Physico-Chemical Systems, June 16-21, 1991, Plymouth, NH.

"Effects of Free and Forced Convection on Near-Limit Premixed Turbulent Flames," V. A. Michelson Conference on Combustion and Explosion, September 17-21, 1990, Moscow, USSR.

Ronney, P. D., "An Experimentalist's View of Combustion Theory," Tenth International Workshop on the Mathematics of Combustion, July 28-30, 1990, Poitiers, France.

"Throttleless Otto-Cycle Natural Gas Engines: NOx Emissions Characteristics," GRI Workshop on NOx Mechanisms in Natural-Gas Flames, July 18-20, 1990, Chateau d'Esclimont, France.

"Applications of Renormalization Group Analysis to Turbulent Combustion: Theoretical and Experimental Considerations," Tsukuba Workshop on Combustion, March 22-23, 1990, Tsukuba, Japan

Ronney, P. D., "Requirements for Temperature and Species Concentration Measurements in Microgravity Combustion Experiments," NASA Noncontact Temperature Measurement Workshop, April 30-May 1, 1987, Washington, D. C.; published in Proceedings of the Noncontact Temperature Measurement Workshop (M. C. Lee, ed.), NASA Conference Publication 2503, 1988, p. 129-138.

Other publications (6)

Ronney, P. D., "A Perspective on the Role of Microgravity in Combustion Research," *Combustion and Flame*, Vol. 116, pp. 317-318 (1999) **(invited contribution).**

Ronney, P. D., "Combustion Experiments on Spacelab Mission MSL-1," in: *Advances in the Astronautical Sciences*, Vol. 91, Peter M. Bainum *et al.,* eds., 1996, pp. 397-407.

Buckmaster, J. D., Ronney, P. D., Smooke, M. "Flame Balls: Past, Present, and Future," AIAA Paper No. 93-0712, 1993.

Ronney, P. D. and Yakhot, V., "Flame Broadening Effects on Premixed Turbulent Flame Speed," in: Turbulent Premixed Flames: A State of the Art (I. Gokalp and M. Champion, eds.), Presses Du CNRS, Paris, France, 1992.

Buckmaster, J. D., Lee, C. J., Joulin, G., Ronney, P. D., "Modelling of Microgravity Ignition Experiments," in: Recent Advances in Combustion Modelling (B. Larrouturou, ed.), Series in Advances in Mathematics for Applied Sciences, Vol. 6, pp. 1-18, World Scientific Press, Teaneck, NJ, 1991.

Ronney, P. D., "An Investigator's Suggestions for Effective Use of the NASA-JSC Reduced Gravity Program KC-135A Aircraft," in: JSC Reduced Gravity Program User's Guide, NASA JSC-22803, July 1991.

Recent presentations (partial list)

Ahn, J., Ronney, P. D., Shao, Z., Haile, S., "A Thermally Self-Sustaining Miniature Solid Oxide Fuel Cell," 4th Joint U.S. Sections Meeting, Combustion Institute, Philadelphia, PA, March 2005.

Ochoa, F., Ronney, P. D., "A thermal transpiration-based self-pressurizing mesoscale combustor" 4th Joint U.S. Sections Meeting, Combustion Institute, Philadelphia, PA, March 2005.

Kuo, C.-H., Ronney, P. D., "Numerical Modeling of Heat Recirculating Combustors," 4th Joint U.S. Sections Meeting, Combustion Institute, Philadelphia, PA, March 2005.

Ahn, J., Ronney, P. D., "Plastic Mesocombustors," 4th Joint U.S. Sections Meeting, Combustion Institute, Philadelphia, PA, March 2005.

Cha, M.-S., Manasra, S., Ronney, P. D., "Propagation Rates of Non-Premixed Edge Flames," 4th Joint U.S. Sections Meeting, Combustion Institute, Philadelphia, PA, March 2005.

Son, Y., Zouein, G., Gokoglu, S., Ronney, P. D., "Comparison of Carbon Dioxide and Helium as Fire Extinguishing Agents for Spacecraft," 4th Joint U.S. Sections Meeting, Combustion Institute, Philadelphia, PA, March 2005.

Theiss, N., Levin, J., Liu, J. B., Zhao, J., Wang, F., Ronney, P. D., Gundersen, M. A., "Transient Plasma Discharge Ignition for Internal Combustion Engines" 4th Joint U.S. Sections Meeting, Combustion Institute, Philadelphia, PA, March 2005.

Ahn, J., Eastwood, C., Ronney, P. D., Zongping, S., Kwak, C., Haile, S., A Thermally Self-Sustaining Miniature Solid Oxide Fuel Cell," 30th Symposium (International) on Combustion, Chicago, IL, July 2004 (poster presentation).

Theiss, N., Levin, J., Liu, J. B., Zhao, J., Wang, F., Ronney, P. D., Gundersen, M. A., "Corona Discharge Ignition for Advanced Stationary Natural Gas Engines" ASME Internal Combustion Engine Division Fall Technical Conference, Long Beach, CA, October 2004.

M. Abid, M., Liu, J.-B., Ronney, P. D., Struk, P. M., Weiland, K. J., "Structure Of Flame Balls At Low Lewis-number (SOFBALL) experiment, *2nd Zeldovich Memorial International Conference on Combustion and Detonation*, Moscow, Russia, September 2004.

Kwon, O. C., Abid, M., Liu, J. B., Ronney, P. D., Struk, P. M., Weiland, K. J., "Structure Of Flame Balls At Low Lewis-number (SOFBALL) Experiment," Paper No. 2004-0289, 42nd AIAA Aerospace Sciences Meeting, Reno, NV, January 5-8, 2004.

Liu, J. B., Wang, F., Lee, L., Ronney, P. D., Gundersen, M. A., "Effect of fuel type on flame ignition by transient plasma discharges," AIAA Paper No. 2004-0837, 42nd AIAA Aerospace Sciences Meeting, Reno, NV, January 5-8, 2004.

Liu, J. B., Wang, F., Lee, L., Ronney, P. D., Gundersen, M. A., "Effect of Discharge Energy and Cavity Geometry on Flame Ignition by Transient Plasma," AIAA Paper No. 2004-1011, 42nd AIAA Aerospace Sciences Meeting, Reno, NV, January 5-8, 2004.

Ahn, J., Eastwood, C., Ronney, P. D., "Extinction Limits of Heat-Recirculating Burners," Fall Technical Meeting, Combustion Institute, Western States Section, October 20-21, 2003, Los Angeles, CA.

Kuo, C. H., Eastwood, C., Ronney, P. D., "Numerical Modeling of Heat-Recirculating Burners," Fall Technical Meeting, Combustion Institute, Western States Section, October 20-21, 2003, Los Angeles, CA.

Son, Y., Zouein, G., Ronney, P., "Instabilities of upward-spreading flames over thermally thick fuels," Fall Technical Meeting, Combustion Institute, Western States Section, October 20-21, 2003, Los Angeles, CA.

Kuo, C. H., , Eastwood, C., Sitzki, L., Borer, K., P., Ronney, P., "Numerical Modeling of Heat-Recirculating Burners," 3rd Joint US Sections Meeting of the Combustion Institute, Chicago, IL, March 21-23, 2003.

Liu, J. B., Ronney, P. D., "Premixed flame ignition by transient plasma discharges," 3rd Joint US Sections Meeting of the Combustion Institute, Chicago, IL, March 21-23, 2003.

Ahn, J., Eastwood, C., Sitzki, L., Borer, K., P., Ronney, P., "Catalytic and Non-Catalytic Combustion in Heat-Recirculating Burners," 3rd Joint US Sections Meeting of the Combustion Institute, Chicago, IL, March 21-23, 2003.

Chen, C., Kwon, O. C., Liu, J., Ronney, P. D., "Strain and heat loss effects on the propagation rates of edge flames," 3rd Joint US Sections Meeting of the Combustion Institute, Chicago, IL, March 21-23, 2003.

Kwon, O. C, Abid, M., Ronney, P. D., Wu, M. S., Ju, Y., "Numerical modeling of flame balls with radiative reabsorption effects," 3rd Joint US Sections Meeting of the Combustion Institute, Chicago, IL, March 21-23, 2003.

Maruta, K., Takeda, K., Sitzki, L., Borer, K., Ronney, P. D., Wussow, S., Deutschmann, O., "Catalytic Combustion in Microchannel for MEMS Power Generation, " Third Asia-Pacific Conference on Combustion, Seoul, Korea, June 24-27, 2001.

Sitzki, L, Borer, K., Schuster, E., Ronney, P. D., Wussow, S., "Combustion in Microscale Heat-Recirculating Burners," Third Asia-Pacific Conference on Combustion, Seoul, Korea, June 24-27, 2001.

Sitzki, L., Borer, K., Wussow, S., Schuster, E., Ronney, P. D. and Cohen, A., "Combustion in Microscale Heat-Recirculating Burners," Paper No. 2001-1087, 39th AIAA Aerospace Sciences Meeting, Reno, NV, January 8-11, 2001.

Honda, L., Son, Y. and Ronney, P. D., "Radiation-Driven Flame Spread Over Thermally-Thick Fuels in Quiescent Microgravity Environments," Paper No. 2001-0467, 39th AIAA Aerospace Sciences Meeting, Reno, NV, January 8-11, 2001.

Abid, M., Aung, K., Ronney, P. D., VanZandt, D. V., "Effects of Lewis Number on Flame Ball Dynamics," Paper No. 2001-0623, 39th AIAA Aerospace Sciences Meeting, Reno, NV, January 8-11, 2001.

Wu, M.-S., Ju, Y. and Ronney, P. D., "Numerical Simulation of Flame Balls with Radiative Reabsorption Effects," Paper No. 2000-0851, 38th AIAA Aerospace Sciences Meeting, Reno, NV, January 11-14, 2000.

Kaiser, C., Liu, J.-B. and Ronney, P. D., "Diffusive-thermal Instability of Counterflow Flames at Low Lewis Number," Paper No. 2000-0576, 38th AIAA Aerospace Sciences Meeting, Reno, NV, January 11-14, 2000.

Abid, M., Sharif, J. and Ronney, P. D., "Premixed-Gas Flame Propagation in Hele-Shaw cells," Spring Technical Meeting, joint U. S. Sections, Combustion Institute, Washington, D.C., March 15-17, 1999.

Liu, J. B. and Ronney, P. D., "Premixed Edge-Flames in Spatially-Varying Straining Flows," Spring Technical Meeting, joint U. S. Sections, Combustion Institute, Washington, D.C., March 15-17, 1999.

Abid, M., Sharif, J. and Ronney, P. D., "Propagating Fronts in Hele-Shaw Cells: Effects of Buoyancy and Thermal Expansion," Spring Technical Meeting, Combustion Institute, Western States Section, Berkeley, CA, March 23-24, 1998.

Sharif, J., Abid, M. and Ronney, P. D., "Mechanisms of Premixed Gas Flame Propagation in Quasi-2D Channels," Fall Technical Meeting, Combustion Institute, Western States Section, Diamond Bar, CA, October 23-24, 1997.

Honda, L. and Ronney, P. D., "Effects of Atmospheric Composition on Flame Spread at Microgravity," Fall Technical Meeting, Combustion Institute, Western States Section, Diamond Bar, CA, October 23-24, 1997.

Abid, M. and Ronney, P. D., "Propagation Rates of Buoyant Chemical Fronts in Aqueous Solution," Fall Technical Meeting, Combustion Institute, Western States Section, University of Southern California, Los Angeles, CA, October 28-29, 1996.

Sharif, J. and Ronney, P. D., "Premixed Gas Flame Propagation in a Hele-Shaw Cell," Fall Technical Meeting, Combustion Institute, Western States Section, University of Southern California, Los Angeles, CA, October 28-29, 1996.

Liu, J. B., Ronney, P. D., "Interferometry System for μg Combustion Experiments," Fall Technical Meeting, Combustion Institute, Western States Section, University of Southern California, Los Angeles, CA, October 28-29, 1996.

Lim, E. H., McIlroy, A., Ronney, P. D., Syage, J. A., "Effect of Spark Kernel Dynamics on Minimum Ignition Energies of Combustible Gases," Fall Technical Meeting, Combustion Institute, Western States Section, University of Southern California, Los Angeles, CA, October 28-29, 1996.

Zhu, J.-Y. and Ronney, P. D., "Numerical Simulation of Buoyant Chemical Front Propagation in Hele-Shaw Flow," 6th SIAM Conference on Numerical Combustion, March 4-6, 1996, New Orleans, LA.

Ronney, P. D., "Dynamics and Pattern Formation in Propagating Chemical Fronts in Buoyant and Turbulent Flows," 15th Dynamics Days Texas, Houston, TX, Jan. 3-6, 1996.

Fortmeyer, J. M. and Ronney, P. D., "Radiatively-Driven Flow in Gases," 48th Annual Meeting, Division of Fluid Dynamics, American Physical Society, Irvine, CA, November 19-21, 1995.

Honda, L. and Ronney, P. D., "Mechanisms of Concurrent-Flow Flame Spread Over Solid Fuels," Fall Technical Meeting, Combustion Institute, Western States Section, Stanford, CA, October 30-31, 1995.

Liu, J. B., Ronney, P. D., "Robust Interferometer System for Drop Tower Experiments," SPIE International Symposium on Optical Science, Engineering, and Instrumentation, July 9-14, 1995, San Diego, CA.

Delichatsios, M. A., Ronney, P. D., "Horizontal and Lateral Flame Spread on Solids: Closure and Diffusional Lewis Number Effects," Fall Technical Meeting, Combustion Institute, Eastern States Section, Dec. 5-7, 1994, Clearwater Beach, FL.

Ronney, P. D., Greenberg, J. B., Zhang, Y., Roegner, E. V., "Control of Fire Spread Through Ambient Atmosphere Effects," 34th Israel Conference on Aerospace Sciences, Feb. 16-17, 1994, Tel-Aviv, Israel.

Wang, Q., Ronney, P. D., "Mechanisms of Flame Propagation Limits in Vertical Tubes," Spring Technical Meeting, Combustion Institute, Eastern/Central States Section, March 15-17, 1993, New Orleans, LA.

UNIVERSITY AND PROFESSIONAL SERVICE

Courses taught

USC:

AME 331 (Heat Transfer) – Spring 2004, Spring 2005
AME 436 (Energy and Propulsion) –Spring 2004, Spring 2005
AME 514 (Applications of Combustion) – Fall 2004 (graduate course)
AME 517 (Radiation heat transfer) – Fall 2003 (graduate course)
ME 310 (Thermodynamics I) - Fall 1993, Fall 1994
ME 331 (Heat Transfer) - Spring 1994, Spring 2000, Spring 2002, Spring 2003
ME 406 (Automotive engines) - Spring 1995, Spring 1996, Spring 1998, Spring 1999, Spring 2002
ME 430 (Thermal systems design) - Fall 1997
ME 436 (Energy and Propulsion) – Fall 1998, Fall 1999, Fall 2000, Fall 2001, Spring 2003
ME 599 (Special topics in combustion) - Fall 1995, Fall 2002 (graduate course)

Princeton:

MAE 435 (Special Topics, Propulsion) - Fall 1986
MAE 221 (Thermodynamics) - Spring 1987, Spring 1988, Spring 1989
MAE 427 (Mobile Power Plants {includes automotive engines, gas turbines and rockets) - Fall 1987, Fall 1988, Fall 1989*, Fall 1990, Fall 1991, Fall 1992
MAE 594 (Combustion) - Spring 1990, Spring 1991, Spring 1992, Spring 1993 (graduate course)

*Received Princeton Engineering Council Excellence in Teaching Award for this class.

Committees

National Advisory Boards

Member, University Space Research Association Microgravity Science Council, 2000 – 2004.

University of Southern California

General Education Committee (1998-2000)

School of Engineering, USC

Chair, Instructional Laboratory Assessment Committee (2001-2003)
Committee on Appointments, Promotions and Tenure (1998-2000)
Research Committee (1999-2001)

Department of Aerospace and Mechanical Engineering, USC

Salary Committee (1994-95)
Seminar Committee (1995-96)
Freshman Advisor (1997-99)

Princeton University

Committee on Undergraduate Life 1987-88

Department of Mechanical and Aerospace Engineering, Princeton University

ASME Faculty Advisor (1986-89)
Seminar Committee (1987-1993)
Freshman Advisor (1987-1992)
Junior Class Advisor (1987-1991)
Senior Class Advisor (1987-1992)
Undergraduate Committee (1987-1992)

Reviewer for manuscripts submitted to

AIAA Journal
AIAA Journal of Propulsion and Power
American Chemical Society Books
Applied Mechanics Reviews
Archivum Combustionitis
ASME Journal of Heat Transfer
Cambridge University Press
Chaos
Combustion Science and Technology
Combustion Theory and Modelling
Combustion and Flame
Experiments in Fluids
Experimental Thermal and Fluid Science
Fire Safety Journal
Fuel
Industrial and Engineering Chemistry Research
International Colloquium on the Dynamics of Explosions and Reactive Systems (13th)
International Symposia on Combustion (21st - 28th)
Journal of Applied Physics
Journal of Fluid Mechanics
Proceedings of the Royal Society of London
Progress in Energy and Combustion Science
Microscale Thermophysical Engineering
Microgravity Science and Technology
National Research Council COBASE program
Nature
Physical Review Letters
Physical Review E
Physics of Fluids
SIAM Journal of Applied Mathematics
Springer-Verlag Publishers

Reviewer for proposals submitted to

METRANS

National Science Foundation
National Aeronautics and Space Administration
Petroleum Research Foundation
State of California Energy Innovations Small Grant Program
U. S. Air Force Office of Scientific Research
U. S. Department of Energy
U. S. State Department International Science and Technology Center
U.S. Civilian Research and Development Foundation
USC Center for Interdisciplinary Research

Honorary Societies

Phi Beta Kappa (Liberal arts)
Tau Beta Pi (Engineering)
Pi Tau Sigma (Mechanical engineering)

Professional Societies

Combustion Institute
American Society of Mechanical Engineers
American Institute of Aeronautics and Astronautics (senior member)
Institute of Physics (Fellow)

Consulting

Sigma-K Corp. – biomass fueled furnaces
Harris Corp. – microscale combustion and power generation
RTI International – microscale combustion and power generation
MEMGen Corp., Torrance, CA - microscale combustion and power generation
Alstom Corp., Hartford CT - laser ignition
Greenrun Engine Co. - natural-gas engine development
General Atomics, San Diego, CA; Flammability and deflagration hazards of CAMDS DFS (Chemical Agent Munition Disposal System, Deactivation Furnace System)